

CONWAY LAKE

LAKES LAY MONITORING PROGRAM

1987

Freshwater Biology Group (FBG)

University of New Hampshire

Durham

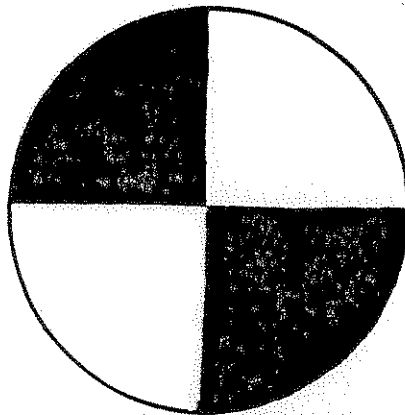
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LAKES LAY MONITORING PROGRAM

To obtain more information about the Lakes Lay Monitoring Program (LLMP) contact the LLMP Coordinator (J. Schloss) at (603) 862-3848, Dr. Baker at 862-3845 or Dr. Haney at 862-2106.

PREFACE

This report contains the findings of a water quality survey of Conway Lake, New Hampshire, conducted jointly by the Freshwater Biology Group (FBG) of the University of New Hampshire and the Walker Pond Conservation Society.

The report is written with the concerned lake resident in mind and contains a brief, non-technical summary of 1987 results as well as more detailed "Introduction" and "Results and Discussion" sections. The description of methods and materials used by the lay monitors and the Freshwater Biology Group has been included in an appendix. While it is common practice to exclude this type of section from a "general" writing such as this, it is our goal to provide the association with a complete report which can stand on its own for comparison to past as well as future lake studies.

This is a Level II+ program report with tabular display of data and a more in-depth discussion of the water quality parameters. While not generally included in reports of this level, some graphic data display has been included in the appendix to aid visual perspective. In addition, listings of data with statistical summaries appear in appendices. The more adventurous reader is referred to these last sections, as well as the materials cited in the references section, if there is interest in learning more about the dynamics of fresh water systems.

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ACKNOWLEDGEMENTS

This was the fifth year of participation in the Lakes Lay Monitoring Program (LLMP) for the Walker Pond Conservation Society. Lay Monitors for Conway Lake were Nancy and Richard Earle, Francis Camp, Pam Fisher, Vivian Fraier and Ed and Marie Morgan. Nancy Earle was the lake coordinator and helped to maintain the LLMP program for the association. We thank the Hill family for their hospitality and for providing a boat for sampling. The Freshwater Biology Group (FBG) congratulates the monitors on the quality of their work, and the time and effort put forth. We encourage these and other interested members of Walker Pond Conservation Society to continue monitoring during the 1988 season. Funding for the program was provided by the Walker Pond Conservation Society.

The Freshwater Biology Group (FBG) is co-supervised by Dr. Alan Baker and Dr. James Haney and coordinated by Jeffrey Schloss. Members of the FBG summer field team included Jeff Schloss, Leanne Hussey Doerthe Fuhlendorf, Paul Schofield and Camilla Girgus. Jeff was responsible for arranging the field trips, training lay monitors, supervising the research team, data interpretation and report writing. Leanne and Camilla were responsible for the preparation of chemical solutions, chlorophyll analysis, and data entry. Paul was responsible for phosphorus chemistry and analysis. All team members participated in field work and chemical analyses. In the fall, Elizabeth

Ferrari assisted in sample processing, data organization and data entry, Dan Helsel processed phosphorus samples and Annette Grace counted zooplankton and assisted the coordinator. The FBG also acknowledges Ann Meade for her time volunteered.

The FBG would like to thank the Institute for Marine Science and Ocean Engineering of the University of New Hampshire for the partial funding of the coordinator position. Eileen Wong of the Department Zoology provided accounting and secretarial service. The College of Life Science and Agriculture provided lab and storage facilities. We would also like to recognize the UNH Office of Computer Services for the provision of computer time and data storage space.

Participating groups in the LLMP for 1987 included: The New Hampshire Audubon Society, Derry Conservation Commission, Nashua Regional Planning Commission, Center Harbor Bay Conservation Commission, Governor's Island Club Inc., Little Island Pond Rod and Gun Club, Walker's Pond Conservation Society, United Associations of Alton, the associations of Baboosic Lake, Beaver Lake, Berry Bay, Big Island Pond, Bow Lake Camp Owners, Lake Chocorua, Great East Lake, Lake Kanasatka Watershed, Langdon Cove, Long Island Landowners, Mendum's Pond, Merrymeeting Lake, Moultonbouro Bay, Lake Winnipесаaukee, Naticook Lake, Newfound Lake, Nippo Lake, Pleasant Lake, Silver Lake (Madison), Squam Lake, Sunset Lake, Lake Winona, and Wentworth Lake and the towns of Alton, Amherst, Hollis, Merrimack and Strafford.

NON-TECHNICAL SUMMARY

Weekly monitoring was undertaken at Conway Lake by the volunteer monitors. An in-depth analysis of Conway Lake was conducted in August by the FBG.

1) Water transparency at Conway Lake was high, the sign of a clear and unproductive lake. The secchi disk was visible as far down as 9.3 meters (30.5 feet). This indicates the deepwater sites on the lake are relatively low in dissolved color and suspended matter such as algae and particulates. Transparency averages in 1987 were slightly greater than the previous year values.

2) Chlorophyll a concentrations for the surface waters of Conway Lake were generally low. Chlorophyll levels indicate the extent of algae growth in the water. Concentrations in the mixed layer of water (the upper 3 to 11 meters) averaged 1.4 milligrams per cubic meter (mg m^{-3} , equivalent to about 1.4 parts chlorophyll per billion parts water). Generally, concentrations below 3 mg m^{-3} are common to less productive, clear lakes and values above 7 mg m^{-3} are common in productive lakes. The 1987 average chlorophyll was less than the 1986 average but remained within the range of past averages.

3) Dissolved lakewater color levels at the deep sites of Conway Lake in 1987 were moderate, slightly above the average levels in other program lakes. The moderate color level is typical of a lake with a forested watershed. Small increases in water color

from the natural breakdown of plant materials in and around a lake are not considered to be detrimental to water quality. However, increased color can lower water transparency, and hence, change the public perception of water quality.

4) Total phosphorus (nutrient) levels were mostly at low levels except for a measurement made during heavy boat traffic at site 1 Andrews. The deeper waters also exhibited low concentrations. All samples but the one discussed above were in the range of 3 to 14 parts per billion (ppb) phosphorus. A concentration of the 15 parts per billion (ppb) is commonly thought of as the boundary between less productive and more productive lakes.

5) For Conway Lake, the total alkalinity, the lakes ability to buffer acid input, remains low and is less than the average alkalinity of all lakes in the program Alkalinity continued to remain at a similar level as previous years. The pH of the surface waters of the lake remains within the optimum range for most aquatic organisms while the deeper waters have lower pH. Alkalinity and pH data from the FBG indicate that Conway Lake has moderate buffering capacity at this time to resist fluctuations in pH due to acid loadings.

6) The specific conductivity of the deep sites on Conway Lake was low and comparable to levels measured in previous years High conductivity values can indicate the presence of septic leachate or de-icing salt runoff.

7) In-depth analyses at the deep site disclosed the typical temperature stratification patterns for northern temperate lakes. Oxygen content of the bottom waters below 9 meters depth was low. Conway Lake bottom waters contained moderate amounts of carbon dioxide, more indicative of a moderately productive lake.

8) The microscopic plants (phytoplankton) were in low to moderate numbers and the microscopic animals (zooplankton) were in moderate numbers at the two deep sites sampled by the FBG. Moderate numbers are generally indicative of more moderately productive lakes. Phytoplankton concentrations were lower in 1987 compared to 1986 but the species composition showed an increased presence of small amounts of nuisance type algae. Chlorophyll measurements at the mid-depths suggests that algae are layering out at the thermocline. This might be an indication of nutrient loading into the lake that has previously gone undetected. Continued monitoring should keep a careful watch on this phenomenon.

9) For all measurements considered and averaged for the season, Conway Lake would be classified as having low productivity, an oligotrophic lake. Phytoplankton and dissolved oxygen profiles are also more indicative of moderate production. Thus Conway Lake waters are of good quality at present but care should be taken, especially in terms of nutrient loading, so as not to augment the productivity level.

10) Comparisons between lay monitor and FBG data indicate that the volunteer monitors of Conway Lake are doing an excellent job of measuring water quality at all stations.

COMMENTS AND RECOMMENDATIONS

1) We recommend that each association along with the Walker Pond Conservation Society, continue to develop their data base on lake water quality through the perpetuation of the long term monitoring program. The data base will provide information on the short and long-term cyclic variability that occurs in the lake and eventually will enable more reliable predictions of water quality trends.

2) As we approach our tenth year in this cooperative lake monitoring effort we are expanding our program options with the help of a one time allocation from the state legislature. Some older equipment will be replaced and new equipment will include rain monitors and fish condition indexing kits. These materials will be provided at no cost to the association. The association should begin to look for interested members who would like participate in these studies.

3) We recommend the continuation of alkalinity testing in 1988 by the lake monitors. Alkalinity indicates the ability of water to buffer acids, and may be more reliable than pH in predicting the effects of acidification on a lake. It is important to establish a data base for alkalinity in order to detect changes as early as possible, especially in lakes such as Conway where the buffering capacity is low.

4) We recommend lay monitor phosphorus testing to be taken during the summer months. As early as possible for the initial sampling combined with sampling of the lake during a times of heavy use (ie: 4 July, Labor Day) and or late in the season when septic systems have been put through a full seasons use.

5) We suggest that all lay monitors continue dissolved color testing on a weekly basis. With low chlorophyll levels, dissolved color information is important for secchi disk transparency interpretations. There is no additional expense for this test. It requires the collection of filtrate from the chlorophyll processing, in small bottles that will be provided. The Freshwater Biology Group will analyze the filtrate by spectrophotometry.

6) FBG oxygen profiles from 1987 and past years have shown a metalimnetic (within the thermocline) oxygen peak at both deep sites. The presence of a metalimnetic population of algae was confirmed in 1987 by the FBG through chlorophyll measurements and phytoplankton examination. These layers of algae may be indicative of nutrient loading. Occasional chlorophyll samples throughout the summer taken at the thermocline using the Meyer Bottle is recommended to monitor this phenomenon.

INTRODUCTION

General Overview

The New Hampshire Lakes Lay Monitoring Program (LLMP) is a research and educational function of the Freshwater Biology Group (FBG) at the University of New Hampshire. The program involves the cooperative participation of lake residents, lake associations, conservation and planning commissions and local governments with University faculty and students. Developed in 1978 around Squam Lake, the program has grown to include more than 50 lakes throughout New Hampshire.

As a long-term research project, the LLMP is investigating the extent of lake degradation caused by perturbations such as acid rain, septic and agricultural runoff, and lakeshore development. Essentially, the volunteer monitors in the program collect data once each week. The data are stored on a computer, the results are analyzed periodically, and interpretive reports are written. The long-term data base permits the detection of both short and long-term changes of the water quality of the lakes. Results from the program are presented at national and international meetings and published in international journals.

As part of its commitment to education through the University, the LLMP trains several undergraduate and graduate students each year to collect and analyze lakewater samples for physical, chemical and biological parameters, and to interpret

water quality data. In addition, more than 350 "lay" monitors have been educated about lake water quality and trained to monitor their own lakes.

As a service to the state and to local communities, the reports of the LLMP are available at cost, and should prove useful to lake residents, conservationists, developers and land-use planners. Also, LLMP staff members conduct workshops, lectures and informal talks on various lake related topics and hold advisory positions on many municipal and private conservation and planning boards. The LLMP is a not-for-profit organization with funding derived primarily from the participating groups and support services provided by the University.

Program Philosophy

Frequent sampling over many years is required to resolve long-term trends and make predictions on the water quality of our lakes. Consider the hypothetical lake in Figure 1. Sampling only once a year during June from 1975 to 1981 would produce a plot (Fig. 1A) suggesting a decrease in eutrophication (the "greening" of a lake). The actual long-term trend of the lake, increasing eutrophy, can only be clearly discerned by sampling more frequently for a longer period (Fig. 1B). Frequent monitoring carried out over the course of many summers can provide the information required to distinguish between short-term fluctuation ("noise") and long-term trends ("signal"). Intensive

sampling of a number of lakes requires more labor than state agencies or universities are able to provide. Based on this premise, with much encouragement from lake associations within the state, the LLMP was conceived in 1978 and initiated in 1979.

The "grass roots approach" to volunteer water quality monitoring is readily apparent upon examination of a typical LLMP sampling kit. The quality of work that can be achieved with equipment constructed from wire, a wine or beer bottle, coffee cans, garden hose and yards of clothes-line has surprised even the most skeptical. These monitoring tools are fun to use and far less intimidating than expensive and complicated scientific apparatus. More importantly, all of the various LLMP sampling kits necessary for the monitoring of a lake can be made for less than the price of a commercially made water sampler.

A major factor in the continued success of our volunteer monitoring program is open communication between the lay monitors and the program staff. Monitors send samples and data sheets to the University on a weekly basis. Each lake has a contact person to coordinate monitoring and act as a liaison between monitors and the FBG. The FBG field team visits each full program lake at least once each summer to collect corroborative data and perform additional analyses. The site visits, along with yearly meetings/workshops held at the university, provide the monitors with program updates and allow for feedback on all aspects of the program.

The quality of work from the volunteers and the lack of constraints from outside sources enables the lay monitors to conduct a wide range of water quality tests (See Figure 2 for a breakdown of basic and optional testing by the lay monitors and the sampling conducted by the FBG field team). Expanded testing and surveys allow for a better understanding of the dynamic inter-relationships of the components of a lake system. Thus, the program provides the necessary information for the intelligent management of our lake resources at minimum cost.

Though not the first volunteer monitoring program, nor the largest in number of volunteers or lakes participating, the LLMP is the most extensive and diverse program of its kind. Through the commitment and enthusiasm of all participants the program is also one of the most long-lived, approaching ten years of operation.

RESULTS AND DISCUSSION OF LAY MONITOR DATA

Results from the lay monitors are presented separately from those obtained by the Freshwater Biology Group, as the two groups conducted separate research.

In 1987, weekly monitoring was done from two sites on Conway Lake (Fig. 3). Lay monitors collected data for water transparency, chlorophyll a and dissolved color concentration, alkalinity, and total phosphorus. See Appendix A for lay monitor data for 1984-1987.

Water Transparency

Secchi Disk depth is a measure of the water transparency. The deeper the depth of secchi disk disappearance, the more transparent the lake water; light penetrates deeper if there is little dissolved and/or particulate matter (which includes both living and non-living particles) to absorb and scatter it. Secchi disk depths greater than 4 meters are typical of clear, less productive lakes. In 1987 values of water transparency at LLMP lakes were in the range 2.5 to 12 meters with a weighted average (by lake) of 6.4 meters.

In the waters around Conway Lake, water transparency (secchi disk depth) was in the range from 3.5 to 6.7 meters with averages of 5.4 meters for both sites 1 and 2.

Secchi disk transparency was low in June increased as the summer progressed into fall (Figures 4 and 5). Average

transparency values would classify Conway Lake as **oligotrophic** (see below). The average transparency in 1987 was greater than the 1986 average for both sites. Site 2 Gull Rock had a greater transparency average (ie. the water was more clear) than any previous year.

Chlorophyll a

The chlorophyll a concentration is a measurement of the standing crop of phytoplankton and is often used to classify lakes into categories of productivity called trophic states. **Eutrophic** lakes are highly productive with large concentrations of algae and aquatic plants due to nutrient enrichment. Summer chlorophyll a concentrations average above 7 mg m^{-3} (one milligram per liter is equivalent to 1 part per billion) **Oligotrophic** lakes have low productivity and low nutrient levels and average summer chlorophyll a concentrations are generally less than 3 mg m^{-3} . **Mesotrophic** lakes are intermediate in productivity with concentrations of chlorophyll a generally between 3 mg m^{-3} and 7 mg m^{-3} . In 1987 chlorophyll a concentrations in LLMP lakes were in the range 0.1 to 7.1 mg m^{-3} with a weighted average (by lake) of 1.5 mg m^{-3} .

Chlorophyll a concentrations were in the range from 0.4 to 2.4 milligrams per cubic meter at the deep sites of Conway Lake. Average chlorophyll concentrations were 1.4 and 1.3 mg m^{-3} respectively for sites 1 and 2. Thus based on 1987 average chlorophyll concentrations, Conway Lake would be classified as

oligotrophic. Concentrations at site 1 did begin to approach more mesotrophic levels in late June (see Figure 6).

Dissolved Color

The dissolved color of lakes is generally due to dissolved organic matter from humic substances, which are naturally-occurring polyphenolic compounds leached from decayed vegetation. Highly colored or "stained" lakes have a "tea" color. Such substances generally do not threaten water quality except as they diminish sunlight penetration into deep waters.

Color is commonly expressed in units of a platinum color standard (ptu). To put the color concentrations in perspective, New Hampshire Lakes studied in 1987 by the Freshwater Biology Group had a range of dissolved color of from essentially 0 ptu to 137 ptu with an unweighted average of 17 ptu. Color samples collected at Conway Lake open water sites ranged from 19 to 38 ptu with an average of 27 ptu. Thus, compared to all LLMP lakes, Conway Lake had moderate dissolved color.

The dissolved color at both sites decreased as the summer progressed (Figure 7). This is typical as most lakes receive the bulk of runoff from the surrounding forested and wetland areas in the spring. Note that water transparency corresponds to a combined effect of algae and color (suggested when Figures 4 through 7 are compared).

Alkalinity

Alkalinity is a measure of the buffering capacity of the lake water. The higher the value the more acid that can be neutralized. Typically lakes in New Hampshire have low alkalinities due to the absence of carbonates and other natural buffering minerals in the bedrock of lake watersheds.

Alkalinity ranged from 3.1 to 4.6 mg CaCO_3 liter⁻¹ with an average of 3.9 mg CaCO_3 liter⁻¹. This is below the average alkalinity of monitored lakes in New Hampshire (about 9.0 mg CaCO_3 liter⁻¹) and lower than the 1987 average for lakes participating in the LLMP (6 mg CaCO_3 liter⁻¹). Average alkalinity for 1987 is comparable to averages from previous years.

Total Phosphorus

Of the two "nutrients" most important to the growth of aquatic plants, nitrogen and phosphorus, it is generally observed that phosphorus is the more limiting to plant growth, and therefore the more important to monitor and control. Phosphorus is generally present in lower concentrations, and its sources primarily originate from anthropogenic activity in a watershed. Nitrogen can be fixed from the atmosphere by many bloom-forming blue-green bacteria, and thus it is difficult to control. The total phosphorus includes all dissolved phosphorus as well as phosphorus contained in or adhered to suspended particulates such as sediment and plankton.

Phosphorus samples were collected at both open water and tributary sites. Concentrations ranged from 3 to 88 ppb. The desirable concentration level of phosphorus is 15 ppb. The high value was taken during a motorboat effect study done in late July. The sample was collected in the area of site 1 after an unusually heavy day of boat traffic. Concentrations measured on the following days were back to more normal levels. Thus, while the motor-boat effect experiment was only preliminary and needs replication and confirmation, there is the suggestion that heavy boating activity may be augmenting nutrient concentration in the upper waters. This may be due to waves from the boats washing nutrients from the shallow shore areas or to prop wash causing the upwelling of nutrients from the bottom waters/sediments. More sampling is necessary to investigate this phenomenon.

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RESULTS AND DISCUSSION OF FBG DATA

The Freshwater Biology Group (FBG) visited Conway Lake on 19 August. The lake was sampled for several chemical, physical and biological parameters at two deep sites (sites 1 Andrews and 2 Gull).

Water Transparency

The secchi disk depth measured by the FBG on Conway Lake was 5.9 and 6.1 meters at sites 1 and 2 respectively. These 1987 FBG transparency measurement fall within the range of lay monitor measurements of 1987 indicating excellent corroboration of the data between the two groups.

Chlorophyll a

Chlorophyll a concentrations from the integrated samples were 1.7 and 1.0 mg per cubic meter (mg m^{-3}) at sites 1 and 2. Samples collected at the thermocline were in higher concentrations, 6.5 and 4.1 milligrams per cubic meter. This indicates the presence of a layering population of algae. As with the secchi disk data, the monitor and FBG results for Conway Lake compare well.

Total Phosphorus

Phosphorus concentrations in the deep waters were low (all below 2 ppb and more indicative of an oligotrophic lake. Upper water phosphorus concentrations were also low. Values below 15 ppb are common in less productive lakes.

Alkalinity

Total alkalinity of the surface waters ranged from 2.8 to 3.0 mg CaCO₃ liter⁻¹. The 1987 values are comparable to values of previous years. The alkalinity of Conway Lake should be monitored closely in the future.

pH

The pH is a way of expressing the acidic level of lake water, and is measured with an electrical probe sensitive to hydrogen ion activity. The pH scale has a range of 1 (very acidic) to 14 (very "basic" or alkaline) and is logarithmic (ie: changes in 1 pH unit reflect an order of magnitude, ie: 10 times, difference in hydrogen ion concentration). Most aquatic organisms tolerate a limited range of pH and most fish species require a pH of 5.5 or higher for successful growth and reproduction.

Surface pH was 5.8 to 6.12 at Conway Lake. The range of surface water pH for all LLMP lakes was 4.9 to 7.5. The pH decreased with depth at the deep sites. This can be attributed to greater carbon dioxide concentration in the bottom waters. At present the pH of Conway Lake in the deeper waters may be falling below the optimum range of many aquatic organisms.

Decreasing alkalinity over a period of a few years can have serious effects on the lake ecosystem. In a study on an experimental acidified lake in Canada (Schindler et al 1985) gradual lowering of the pH from 6.8 to 5.0 in an 8-year period resulted in the disappearance of some aquatic species, an increase in nuisance species of algae and a decline in the

condition and reproduction rate of fish. During the first year of Schindler's study the pH remained unchanged while the alkalinity declined to 20 percent of the pre-treatment value. The decline in alkalinity was sufficient to trigger the disappearance of zooplankton species, which in turn caused a decline in the "condition" of fish species that fed on the zooplankton. Thus, while the current pH levels at the lake have generally remained constant during the past few years it is important to continue monitoring these parameters as well as to start monitoring fish condition to detect for any deleterious effects of acid rain.

Specific Conductivity

The specific conductance of a water sample indicates concentrations of dissolved salts. Leaking septic systems and de-icing salt runoff from highways can cause high conductivity values. Conductivity values at Conway Lake were in the range of 30 to 32 micro-Siemans. These values are comparable to values measured in previous years.

Stratification in the Deep Water Sites

Profiles of temperature for the deep sites studied show a distinct pattern of temperature stratification where a layer of warmer water (the epilimnion) overlies a deeper layer of cold water (hypolimnion). The layer that separates the two regions is characterized by a sharp drop in temperature with depth and is called the thermocline or metalimnion.

The epilimnetic depth for the Conway Lake deep sites was 5.0 meters at site 1 and 4.5 meters at site 2 on 19 August. The hypolimnion was well developed at site 1 from about 12 meters down to the lake bottom.

Dissolved Oxygen and Free CO₂

At Conway Lake oxygen decreased with depth and the waters below 7 meters had low concentrations. In more productive lakes the large amounts of organic matter produced in the upper waters settles to the bottom where bacterial decomposition of the matter consumes the oxygen. Oxygen is also depleted by the respiration of other organisms (which includes all aerobic life, plants as well as animals) and by chemical reactions. Decrease in the oxygenated area in a lake restricts the depths at which fish and plants can survive. Anoxic conditions also cause decomposition processes to slow down so organic matter can accumulate at the bottom of the lake. Nutrients which normally are bound into the sediments in oxygenated waters are not trapped as well and become available in larger quantities when spring and fall mixing occurs. Thus, in lakes lacking oxygen in their deep waters these nutrients contribute to the growth of algae and are a form of "nutrient loading".

Carbon dioxide in the hypolimnion was moderate. Carbon dioxide is generated and can accumulate in aquatic systems as a result of the respiration of a wide variety of organisms in the water. Plants (including the phytoplankton) take up free carbon dioxide and produce oxygen during the day, but respire at night

along with the aquatic animals and bacteria. Carbon dioxide usually accumulates in the bottom waters of more productive systems where large amounts of organic material, produced within and around the lake, support large bacterial populations. Breakdown of organic matter, respiration and fermentation, by the bacteria in the water and sediments, consumes oxygen and releases carbon dioxide. Increases in dissolved carbon dioxide result in the decrease of the lakewater pH.

Zooplankton

There are three groups of zooplankton that are generally dominant in lakes: the **protozoa**, **rotifers** and **crustaceans**. Most research has been devoted to the last two groups although protozoa may be found in substantial amounts. Of the rotifers and the crustaceans, time and budgetary constraints made it necessary to sample only the larger zooplankton (macrozooplankton; larger than 150 microns). Thus, zooplankton analysis was restricted only to the larger crustaceans. The crustaceans can be divided into two groups, the **cladocerans** (which include the "water fleas") and the **copepods**.

Macrozooplankton are an important component in the lake system. The filter feeding of the herbivorous ("grazing") species may control the population size of selected species of phytoplankton. The larger zooplankton can be an important food source for juvenile and adult planktivorous fish. All zooplankton play a part in the recycling of nutrients within the lake.

Zooplankton undergo seasonal population cycles and the results discussed below are most representative of the three collection dates and not necessarily of other times during the ice-free season, especially during the early spring and late fall.

The macrozooplankton concentration on Conway Lake was 6.7 organisms per liter for site 1, and 5.9 organisms per liter for site 2 on 19 August. Concentrations between 1 and 10 per liter are considered moderate, concentrations over 10 per liter are considered high. Thus, Conway Lake concentrations were moderate. The dominant herbivores ("phytoplankton eaters") were a species of calanoid copepod, Diaptomus. Predatory ("zooplankton eating") cyclopoid copepods were also found in high numbers along with the small herbivorous cladoceran Diaphanosoma. High densities of Diaphanosoma have often been associated with lake water containing high amounts of detritus and bacteria. The diversity of zooplankton was fair to good. High diversity of zooplankton is generally thought to be a good sign in terms of the "health" of a lake.

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FIGURES

Figure 1. Hypothetical example in which limited sampling of a lake can be very deceptive. The upper graph (A) depicts the results of sampling only once a year in June. The indicated trend seems to be that of decreasing eutrophy. However, weekly sampling of the same lake over a longer period of time would produce the lower graph (B). The actual long-term trend is that of increasing eutrophy. The circled area in the lower graph is an enlargement of the data-set used to produce the upper graph.

RESOLUTION OF LONG-TERM TREND

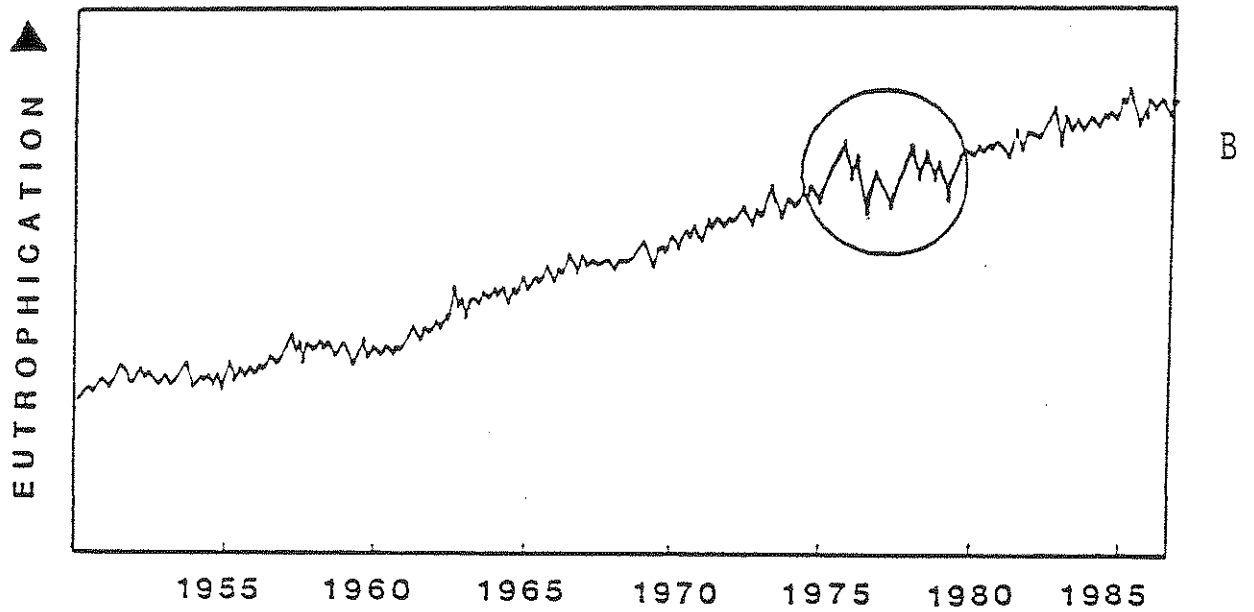
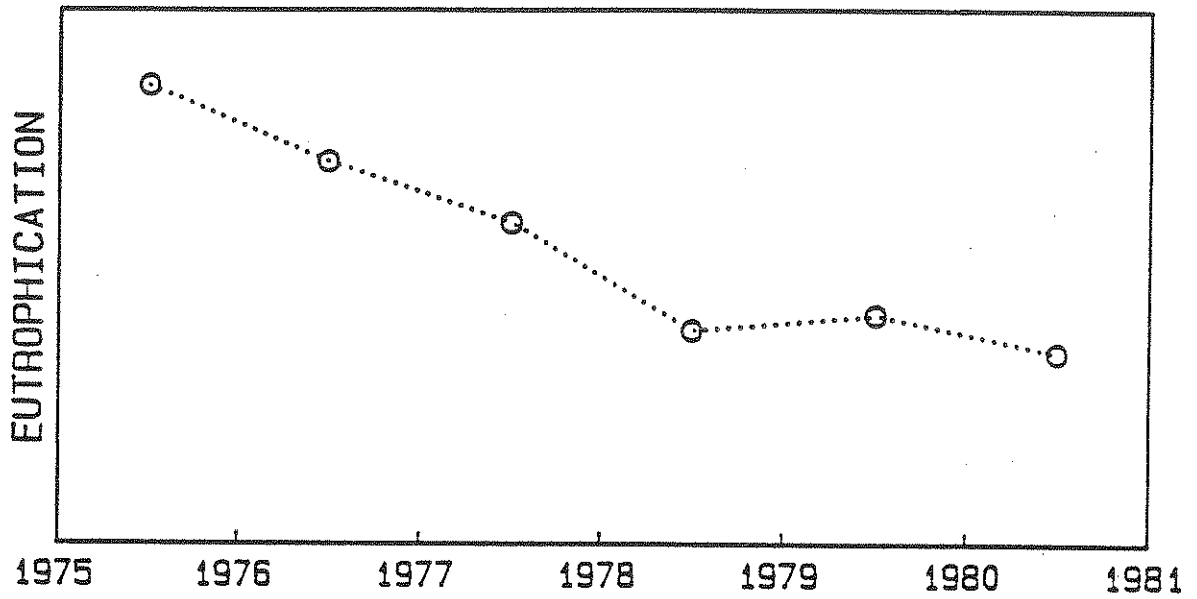


Figure 2. Diagram indicating the water quality parameters tested by participants in the New Hampshire Lakes Lay Monitoring Program. Sampling is conducted by two groups: Volunteer monitors and the Freshwater Biology Group summer field team. Each test is coded as to the type of sample collected and which group does the processing (see key).

LAKES LAY MONITORING PROGRAM - PARAMETERS SAMPLED

LAY MONITORS

SECCHI DISK TRANSPARENCY

TEMPERATURE PROFILE

CHLOROPHYLL a *I

DISSOLVED COLOR *I,T

TOTAL PHOSPHORUS *I,T

TOTAL ALKALINITY I,T

PH I,T

METALIMNETIC CHLOROPHYLL a *P

FISH CONDITION

Length/Weight Index

Age Classification *

MOTORBOAT EFFECTS

AQUATIC VEGETATION SURVEY

BASIC PROGRAM

ADVANCED OPTIONS

DATA
CORROBORATION

FRESHWATER BIOLOGY GROUP

SECCHI DISK TRANSPARENCY

TEMPERATURE PROFILE

CHLOROPHYLL a I

DISSOLVED COLOR I,T

TOTAL PHOSPHORUS I,P,T

TOTAL ALKALINITY I,M,T

PH I,M,T

METALIMNETIC CHLOROPHYLL a P

UNDERWATER LIGHT PROFILE

DISSOLVED OXYGEN PROFILE

FREE CARBON DIOXIDE M

SPECIFIC CONDUCTIVITY M,T

PHYTOPLANKTON I,M

ZOOPLANKTON V

^BACTERIA P,T

Total Coliform

Fecal Coliform

Fecal Strep.

^FISH CONDITION

^AQUATIC VEGETATION SURVEY

KEY

*- Sample collected by Lay Monitor, processed by FBG.

I- Integrated epilimnetic sample.

P- Point sample, single depth.

M- Point samples, multiple depths.

T- Tributary samples.

V- Vertical tow through oxygenated depths.

^- Optional parameters, sampled if requested.

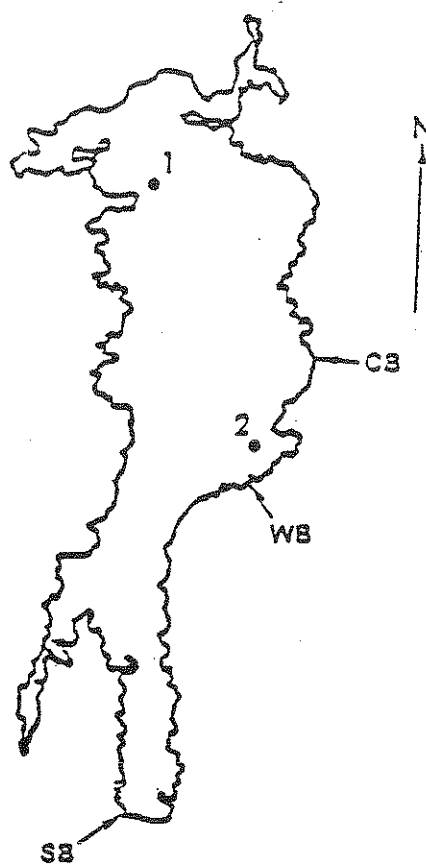
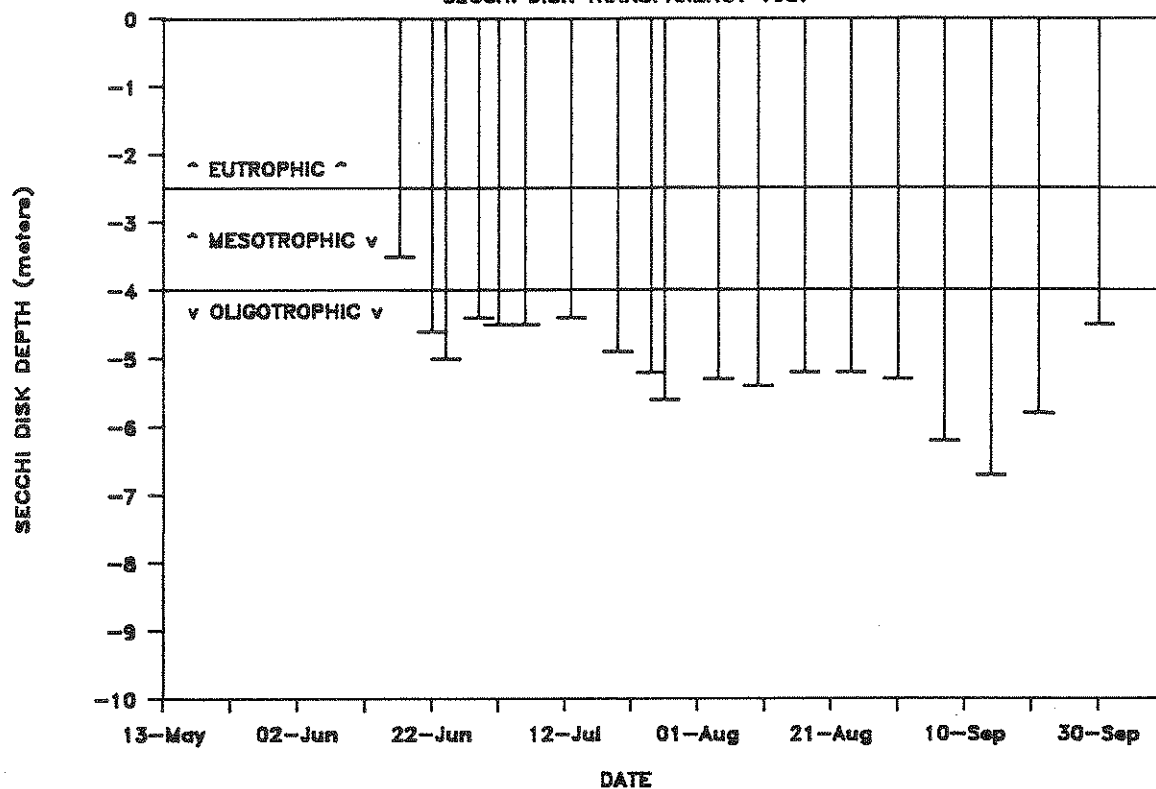


Figure 3. Location of sampling sites for Conway Lake, New Hampshire.

Figures 4 and 5. - Seasonal trends for secchi disk depth (water transparency) for sites 1 Andrews (4), and 2 Gull Rock (5), Conway Lake. Solid lines on the plots border the ranges common to oligotrophic, mesotrophic and eutrophic lakes.

SECCHI: DISK TRANSPARENCY 1987



SECCHI DISK TRANSPARENCY 1987

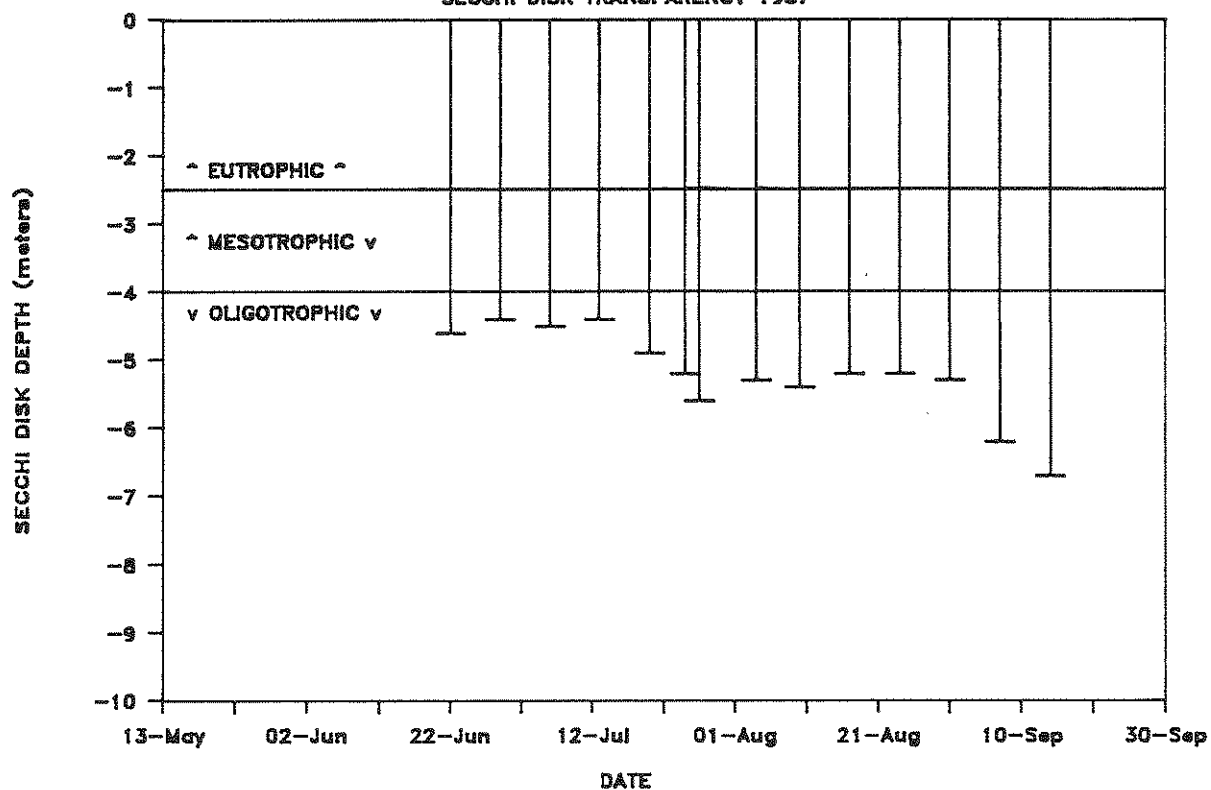
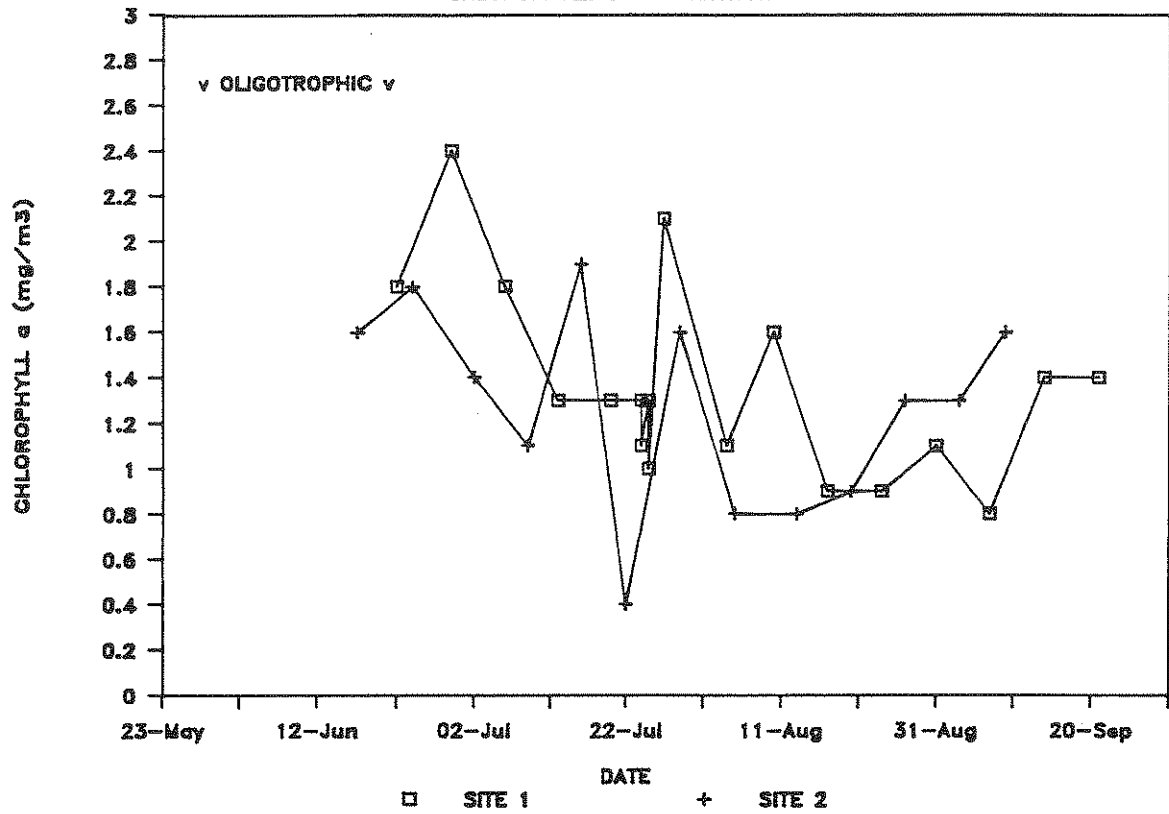


Figure 6. Seasonal trends for chlorophyll a concentration for the two lake sites sampled on Conway Lake. determined from lay monitor data. Solid lines on the plots border the ranges common to oligotrophic and mesotrophic lakes.

Figure 7. Seasonal trends for dissolved color concentration for the two lake sites sampled on Conway Lake determined from lay monitor data. Solid line indicates the average dissolved color for all LLMP lakes in 1987, weighted by lake.

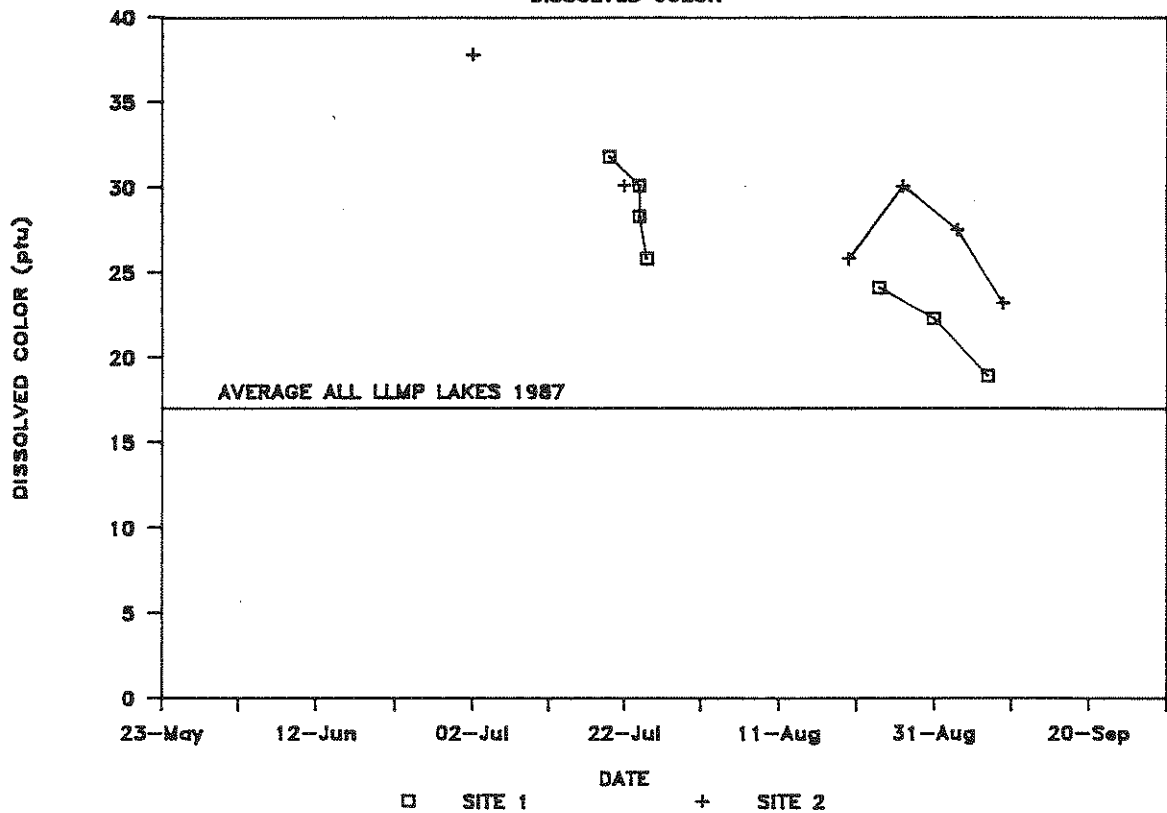
CONWAY LAKE 1987

CHLOROPHYLL *a* CONCENTRATION



CONWAY LAKE 1987

DISSOLVED COLOR



Conway Lake Data On File as of 04/16/1988

Lakes Lay Monitoring Program, U.N.H.

[Lay Monitor Data]

Conway Lake of Center Conway, NH

-- subset of trophic indicators, all sites, 1983

1983 SUMMARY

Average transparency: 5.6 (1983: 27 values)

Average chlorophyll: 1.2 (1983: 27 values)

Site	Date	Trans- parency (m)	Chl a (ppb)	Total Phos (ppb)	Alk. (gray) ph 5.1	Alk. (pink) ph 4.6	Color Pt-Co units
1 Andrews	06/19/1983	4.9	1.4	---	---	---	---
1 Andrews	07/07/1983	---	1.6	---	---	---	---
1 Andrews	07/14/1983	4.7	1.1	---	---	---	---
1 Andrews	07/21/1983	5.5	0.8	---	---	---	---
1 Andrews	07/28/1983	6.5	1.1	---	---	---	---
1 Andrews	08/05/1983	6.2	1.1	---	---	---	---
1 Andrews	08/11/1983	6.1	1.0	---	---	---	---
1 Andrews	08/18/1983	5.8	0.6	---	---	---	---
1 Andrews	08/25/1983	5.7	---	---	---	---	---
1 Andrews	09/01/1983	6.6	2.3	---	---	---	---
1 Andrews	09/09/1983	7.5	2.6	---	---	---	---
1 Andrews	09/15/1983	7.4	1.0	---	---	---	---
1 Andrews	09/22/1983	6.0	1.0	---	---	---	---
1 Andrews	10/06/1983	5.8	1.5	---	---	---	---
1 Andrews	10/19/1983	4.3	1.2	---	---	---	---
2 Gull	06/19/1983	5.6	1.0	---	---	---	---
2 Gull	07/11/1983	4.8	0.8	---	---	---	---
2 Gull	07/16/1983	4.8	1.0	---	---	---	---
2 Gull	07/23/1983	4.6	0.6	---	---	---	---
2 Gull	07/31/1983	5.2	0.9	---	---	---	---
2 Gull	08/05/1983	5.5	0.4	---	---	---	---
2 Gull	08/14/1983	5.1	1.5	---	---	---	---
2 Gull	08/21/1983	4.0	1.2	---	---	---	---
2 Gull	08/27/1983	4.5	2.5	---	---	---	---
2 Gull	09/04/1983	4.9	1.1	---	---	---	---
2 Gull	09/20/1983	6.8	0.9	---	---	---	---
2 Gull	09/27/1983	5.8	1.3	---	---	---	---
2 Gull	10/04/1983	6.1	0.9	---	---	---	---

<< End of 1983 listing, 28 records >>

Conway Lake Data On File as of 04/16/1988

Lakes Lay Monitoring Program, U.N.H.

[Lay Monitor Data]

Conway Lake of Center Conway, NH

-- subset of trophic indicators, all sites, 1984

1984 SUMMARY

Average transparency: 5.5 (1984: 18 values)
Average chlorophyll: 1.1 (1984: 18 values)

Site	Date	Trans- parency (m)	Chl a (ppb)	Total Phos (ppb)	Alk. (gray) ph 5.1	Alk. (pink) ph 4.6	Color Pt-Co units
1 Andrews	07/11/1984	5.0	1.3	---	---	---	---
1 Andrews	07/18/1984	4.8	1.4	---	---	---	---
1 Andrews	07/25/1984	5.3	2.3	---	---	---	---
1 Andrews	08/01/1984	5.5	2.8	---	---	---	---
1 Andrews	08/08/1984	6.3	0.8	---	---	---	---
1 Andrews	08/15/1984	6.4	0.6	---	---	---	---
1 Andrews	08/22/1984	6.1	0.8	---	---	---	---
1 Andrews	08/30/1984	6.4	0.6	---	---	---	---
1 Andrews	09/05/1984	6.7	1.5	---	---	---	---
2 Gull	07/26/1984	4.5	1.9	---	---	---	---
2 Gull	08/01/1984	4.8	0.4	---	---	---	---
2 Gull	08/09/1984	5.8	0.6	---	---	---	---
2 Gull	08/15/1984	5.5	0.4	---	---	---	---
2 Gull	08/22/1984	5.8	1.1	---	---	---	---
2 Gull	08/29/1984	5.2	0.7	---	---	---	---
2 Gull	09/06/1984	4.4	0.8	---	---	---	---
2 Gull	09/13/1984	5.5	1.1	---	---	---	---
2 Gull	09/20/1984	5.0	1.5	---	---	---	---

<< End of 1984 listing, 18 records >>

Conway Lake Data On File as of 04/16/1988

Lakes Lay Monitoring Program, U.N.H.

[Lay Monitor Data]

Conway Lake of Center Conway, NH

-- subset of trophic indicators, all sites, 1985

1985 SUMMARY

Average transparency:	5.8	(1985:	28	values)
Average chlorophyll:	0.8	(1985:	28	values)
Average alk (gray):	3.8	(1985:	15	values)
Average alk (pink):	4.4	(1985:	15	values)
Average color, 440:	12.2	(1985:	8	values)

Site	Date	Trans- parency (m)	Chl a (ppb)	Total Phos (ppb)	Alk. (gray) ph 5.1	Alk. (pink) ph 4.6	Color Pt-Co units
1 Andrews	07/02/1985	5.5	0.6	---	---	---	---
1 Andrews	07/08/1985	5.5	0.6	---	---	---	---
1 Andrews	07/15/1985	5.7	0.6	---	---	---	9.2
1 Andrews	07/22/1985	6.0	0.7	---	---	---	13.5
1 Andrews	07/29/1985	6.5	0.9	---	---	---	3.2
1 Andrews	08/04/1985	6.7	0.7	---	---	---	15.2
1 Andrews	08/12/1985	7.2	0.3	---	3.6	4.8	---
1 Andrews	08/19/1985	6.8	0.4	---	3.9	4.4	---
1 Andrews	08/26/1985	7.2	0.9	---	3.8	4.5	---
1 Andrews	09/02/1985	7.5	0.9	---	3.5	4.0	---
1 Andrews	09/09/1985	7.5	0.7	---	3.1	4.2	---
1 Andrews	09/16/1985	6.3	0.8	---	4.1	4.6	---
1 Andrews	09/23/1985	6.7	0.4	---	3.6	4.0	---
1 Andrews	09/30/1985	4.8	0.9	---	4.6	4.9	---
1 Andrews	10/07/1985	5.0	0.8	---	3.7	4.1	---
2 Gull	06/21/1985	5.0	2.9	---	---	---	---
2 Gull	06/29/1985	4.0	3.2	---	---	---	---
2 Gull	07/06/1985	4.5	0.5	---	---	---	---
2 Gull	07/12/1985	5.0	0.6	---	---	---	16.1
2 Gull	07/20/1985	4.2	0.5	---	---	---	11.8
2 Gull	07/27/1985	4.7	0.7	---	---	---	10.1
2 Gull	07/31/1985	5.2	0.8	---	---	---	18.6
2 Gull	08/10/1985	5.5	0.4	---	4.4	4.8	---
2 Gull	08/16/1985	5.1	0.6	---	3.9	4.3	---
2 Gull	08/23/1985	6.2	0.6	---	3.9	4.5	---
2 Gull	09/01/1985	6.8	0.9	---	3.9	4.4	---
2 Gull	09/15/1985	5.4	0.4	---	3.8	4.3	---
2 Gull	10/08/1985	5.6	0.6	---	3.9	4.3	---

<< End of 1985 listing, 28 records >>

Conway Lake Data On File as of 04/16/1988

Lakes Lay Monitoring Program, U.N.H.

[Lay Monitor Data]

Conway Lake of Center Conway, NH

-- subset of trophic indicators, all sites, 1986

1986 SUMMARY

Average transparency:	4.7	(1986:	27	values)
Average chlorophyll:	2.8	(1986:	26	values)
Average phosphorus:	7.9	(1986:	5	values)
Average alk (gray):	3.8	(1986:	26	values)
Average alk (pink):	4.3	(1986:	26	values)
Average color, 440:	19.5	(1986:	15	values)

Site	Date	Trans- parency (m)	Chl a (ppb)	Total Phos (ppb)	Alk. (gray) ph 5.1	Alk. (pink) ph 4.6	Color Pt-Co units
1 Andrews	06/23/1986	4.5	4.3	---	3.7	4.2	---
1 Andrews	07/01/1986	4.4	4.0	---	3.9	4.4	---
1 Andrews	07/07/1986	4.7	6.1	---	3.8	4.2	21.2
1 Andrews	07/14/1986	5.7	3.8	---	3.6	4.1	---
1 Andrews	07/21/1986	5.6	1.3	---	4.0	4.5	16.9
1 Andrews	07/28/1986	4.8	1.9	---	4.1	4.6	---
1 Andrews	08/04/1986	5.8	2.2	---	3.7	4.2	22.9
1 Andrews	08/11/1986	5.2	2.4	---	3.6	4.0	17.8
1 Andrews	08/18/1986	5.2	1.6	---	3.6	3.9	19.5
1 Andrews	08/25/1986	5.2	3.5	---	3.9	4.3	---
1 Andrews	08/28/1986	---	---	---	---	---	15.2
1 Andrews	09/01/1986	4.7	3.7	---	3.5	4.0	18.6
1 Andrews	09/08/1986	4.8	3.0	---	3.9	4.3	20.4
1 Andrews	09/15/1986	3.8	2.1	---	3.9	4.4	---
1 Andrews	09/22/1986	4.2	2.8	---	4.0	4.4	---
1 Andrews	10/06/1986	4.2	---	---	---	---	---
2 Gull	06/27/1986	4.0	4.2	---	4.5	5.0	---
2 Gull	07/03/1986	4.8	4.4	---	4.0	4.5	---
2 Gull	07/11/1986	4.7	3.6	---	3.8	4.4	15.2
2 Gull	07/17/1986	4.7	3.1	---	4.1	4.5	---
2 Gull	07/23/1986	4.8	1.1	---	3.7	4.1	19.5
2 Gull	08/01/1986	3.5	1.7	6.0	4.0	4.4	22.1
2 Gull	08/08/1986	5.0	1.5	---	3.5	4.0	---
2 Gull	08/13/1986	4.5	1.7	---	3.8	4.1	20.4
2 Gull	08/21/1986	5.0	1.7	---	3.9	4.2	23.8
2 Gull	08/30/1986	4.0	2.6	---	4.1	4.5	21.2
2 Gull	09/05/1986	4.3	2.3	---	2.5	3.0	---
2 Gull	09/12/1986	4.5	2.4	---	4.1	4.6	17.8
T-1 Snow	04/17/1986	---	---	7.0	---	---	---
T-2 Unkwn	04/17/1986	---	---	7.5	---	---	---
T-3 Brdgl	04/17/1986	---	---	8.0	---	---	---
T-4 Willey	04/17/1986	---	---	11.0	---	---	---

Conway Lake Data On File as of 04/16/1988

<< End of 1986 listing, 32 records >>

Conway Lake Data On File as of 04/16/1988

Lakes Lay Monitoring Program, U.N.H.

[Lay Monitor Data]

Conway Lake of Center Conway, NH

-- subset of trophic indicators, all sites, 1986

1986 SUMMARY

Average transparency:	4.7	(1986:	27	values)
Average chlorophyll:	2.8	(1986:	26	values)
Average phosphorus:	7.9	(1986:	5	values)
Average alk (gray):	3.8	(1986:	26	values)
Average alk (pink):	4.3	(1986:	26	values)
Average color, 440:	19.5	(1986:	15	values)

Site	Date	Trans- parency (m)	Chl a (ppb)	Total Phos (ppb)	Alk. (gray) ph 5.1	Alk. (pink) ph 4.6	Color Pt-Co units
1 Andrews	06/23/1986	4.5	4.3	---	3.7	4.2	---
1 Andrews	07/01/1986	4.4	4.0	---	3.9	4.4	---
1 Andrews	07/07/1986	4.7	6.1	---	3.8	4.2	21.2
1 Andrews	07/14/1986	5.7	3.8	---	3.6	4.1	---
1 Andrews	07/21/1986	5.6	1.3	---	4.0	4.5	16.9
1 Andrews	07/28/1986	4.8	1.9	---	4.1	4.6	---
1 Andrews	08/04/1986	5.8	2.2	---	3.7	4.2	22.9
1 Andrews	08/11/1986	5.2	2.4	---	3.6	4.0	17.8
1 Andrews	08/18/1986	5.2	1.6	---	3.6	3.9	19.5
1 Andrews	08/25/1986	5.2	3.5	---	3.9	4.3	---
1 Andrews	08/28/1986	---	---	---	---	---	15.2
1 Andrews	09/01/1986	4.7	3.7	---	3.5	4.0	18.6
1 Andrews	09/08/1986	4.8	3.0	---	3.9	4.3	20.4
1 Andrews	09/15/1986	3.8	2.1	---	3.9	4.4	---
1 Andrews	09/22/1986	4.2	2.8	---	4.0	4.4	---
1 Andrews	10/06/1986	4.2	---	---	---	---	---
2 Gull	06/27/1986	4.0	4.2	---	4.5	5.0	---
2 Gull	07/03/1986	4.8	4.4	---	4.0	4.5	---
2 Gull	07/11/1986	4.7	3.6	---	3.8	4.4	15.2
2 Gull	07/17/1986	4.7	3.1	---	4.1	4.5	---
2 Gull	07/23/1986	4.8	1.1	---	3.7	4.1	19.5
2 Gull	08/01/1986	3.5	1.7	6.0	4.0	4.4	22.1
2 Gull	08/08/1986	5.0	1.5	---	3.5	4.0	---
2 Gull	08/13/1986	4.5	1.7	---	3.8	4.1	20.4
2 Gull	08/21/1986	5.0	1.7	---	3.9	4.2	23.8
2 Gull	08/30/1986	4.0	2.6	---	4.1	4.5	21.2
2 Gull	09/05/1986	4.3	2.3	---	2.5	3.0	---
2 Gull	09/12/1986	4.5	2.4	---	4.1	4.6	17.8
T-1 Snow	04/17/1986	---	---	7.0	---	---	---
T-2 Unkwn	04/17/1986	---	---	7.5	---	---	---
T-3 Brdgl	04/17/1986	---	---	8.0	---	---	---
T-4 Willey	04/17/1986	---	---	11.0	---	---	---

Conway Lake Data On File as of 04/16/1988

<< End of 1986 listing, 32 records >>

Conway Lake Data On File as of 04/16/1988

Lakes Lay Monitoring Program, U.N.H.

[Lay Monitor Data]

Conway Lake of Center Conway, NH

-- subset of trophic indicators, all sites, 1987

1987 SUMMARY

Average transparency:	5.4	(1987:	33	values)
Average chlorophyll:	1.3	(1987:	32	values)
Average phosphorus:	18.0	(1987:	7	values)
Average alk (gray):	3.9	(1987:	31	values)
Average alk (pink):	4.4	(1987:	31	values)
Average color, 440:	23.6	(1987:	14	values)

Site	Date	Trans- parency (m)	Chl a (ppb)	Total Phos (ppb)	Alk. (gray) ph 5.1	Alk. (pink) ph 4.6	Color Pt-Co units
1 Andrews	06/22/1987	4.6	1.8	---	4.2	4.8	---
1 Andrews	06/29/1987	4.4	2.4	---	3.5	4.0	---
1 Andrews	07/06/1987	4.5	1.8	---	3.6	4.2	---
1 Andrews	07/13/1987	4.4	1.3	---	4.3	4.8	---
1 Andrews	07/20/1987	4.9	1.3	---	4.1	4.5	28.1
1 Andrews	07/24/1987	5.1	1.3	13.3	4.3	4.7	26.4
1 Andrews	07/24/1987	5.6	1.1	88.0	4.2	4.8	24.7
1 Andrews	07/25/1987	9.3	1.3	5.3	4.2	4.7	22.1
1 Andrews	07/25/1987	5.2	1.0	---	4.2	4.7	22.1
1 Andrews	07/27/1987	5.6	2.1	---	4.3	4.7	---
1 Andrews	08/04/1987	5.3	1.1	---	4.0	4.4	---
1 Andrews	08/10/1987	5.4	1.6	---	4.1	4.5	---
1 Andrews	08/17/1987	5.2	0.9	---	3.5	3.9	---
1 Andrews	08/24/1987	5.2	0.9	---	3.8	4.2	20.4
1 Andrews	08/31/1987	5.3	1.1	---	3.5	3.9	18.6
1 Andrews	09/07/1987	6.2	0.8	---	3.7	4.1	15.2
1 Andrews	09/14/1987	6.7	1.4	---	3.7	4.2	---
1 Andrews	09/21/1987	5.8	1.4	---	3.7	4.1	---
1 Andrews	09/30/1987	4.5	---	---	---	---	---
2 Gull	06/17/1987	3.5	1.5	---	4.0	4.6	---
2 Gull	06/24/1987	5.0	1.6	---	4.0	4.5	---
2 Gull	07/02/1987	4.5	1.8	---	4.0	4.3	34.1
2 Gull	07/09/1987	4.5	1.4	---	---	---	---
2 Gull	07/16/1987	4.5	1.1	---	4.2	4.7	---
2 Gull	07/22/1987	5.6	1.9	---	4.3	4.8	26.4
2 Gull	07/29/1987	6.0	0.4	3.3	4.0	4.5	---
2 Gull	08/05/1987	6.0	1.6	---	4.2	4.6	---
2 Gull	08/13/1987	6.7	0.8	---	3.9	4.3	---
2 Gull	08/20/1987	6.0	0.8	---	3.9	4.3	22.1
2 Gull	08/27/1987	5.9	0.9	---	3.8	4.1	26.4
2 Gull	09/03/1987	5.5	1.3	---	3.6	4.0	23.8
2 Gull	09/09/1987	6.0	1.3	---	3.8	4.2	19.5

Conway Lake Data On File as of 04/16/1988

Site	Date	Trans- parency (m)	Chl a (ppb)	Total Phos (ppb)	Alk. (gray) ph 5.1	Alk. (pink) ph 4.6	Color Pt-Co units
2 Gull	09/16/1987	5.7	1.6	2.7	3.7	4.2	---
T-4 Willey	04/10/1987	---	---	6.3	---	---	---
T-5 Clarke	04/16/1987	---	---	7.0	---	---	---

<< End of 1987 listing, 35 records >>

METHODS OF LAY MONITORS

Lay monitors receive their initial training either on-site or on campus from a member of the FBG. Workshops covering new techniques are usually offered on a yearly basis and updates may be held on-site during an FBG sampling trip.

This year data were collected on seven parameters: thermal stratification, water clarity (secchi disk depth), chlorophyll a concentration, dissolved color, total alkalinity and total phosphorus. Whenever possible, testing was done weekly between the hours of 9 am and 3 pm, the period of maximum sunlight penetration into the water. All samples and data were mailed or hand delivered to the FBG at UNH for analysis.

Thermal (temperature) profiles were obtained by collecting lakewater samples at several successive depths using a modified Meyer bottle (Lind, 1979). A weighted, stoppered, empty bottle was lowered to a specific depth. At that depth, the stopper was pulled, allowing the bottle to be filled with water. The bottle was quickly pulled back up to the surface where the temperature of the sample was taken with a Taylor pocket thermometer, and recorded in degrees C. This procedure was repeated at one meter intervals through the epilimnion (upper water column), at one-half meter intervals throughout the metalimnion (depths at which the temperature change is greater than 1 degree C per meter) and at one meter intervals through the hypolimnion (depths below the metalimnion).

Water clarity was measured by lowering a secchi disk (approximately 20 cm. or 8 inches) through the water off the shaded side of the boat, and noting the average of the depths at which it disappeared upon lowering and reappeared when being raised (the cord attached to the secchi disk is marked in one tenth of a meter for the first half meter and in one-half meters thereafter). Water clarity was determined while holding a view-scope just below the surface to eliminate effects of surface reflection and wave action. This was repeated two or three times, and an average to the nearest one-tenth of a meter was recorded.

Chlorophyll a concentration was used as an index of algal biomass that is useful in determining the trophic state of the lake. A weighted plastic tube (10 meters in length) was lowered through the epilimnion to the top of the metalimnion (the depths of the epilimnion and metalimnion are determined from the temperature profile). The end of the tube above water is folded to shut off the water flow into or out of the tube. The weighted end of the tube is pulled up out of the water with an attached cord, trapping an integrated sample of water representing the "upper lake" in the tube. This sample is poured into a blue plastic 2.5 liter bottle and stored in the shade until chlorophyll filtration could be done.

Water samples for chlorophyll a filtration were filtered through a 0.45 micron membrane filter under low vacuum. Damp filters, containing chlorophyll-bearing algae, were air-dried for at least 15 minutes, in the dark, to prevent decomposition or

bleaching of the chlorophyll on the filter. A sample of the filtrate was poured into a 60 ml plastic bottle for the determination of dissolved water color. These filters and bottles were delivered to UNH where members of the FBG analyzed them for chlorophyll a and dissolved water color (see Methods of the Freshwater Biology Group).

METHODS OF THE FRESHWATER BIOLOGY GROUP

The Freshwater Biology Group (FBG) research team took one trip to the Conway Lake and conducted several tests which included measurements of sunlight penetration into the water, dissolved oxygen, temperature, alkalinity, free (unbound) carbon dioxide, pH, specific conductivity, chlorophyll a, dissolved color, total phosphorus, and a survey of the microscopic plants (phytoplankton) and animals (zooplankton). The FBG also processed chlorophyll a, dissolved color, and phosphorus samples provided by the lay monitors. The input, storage and analysis of all LLMP data is also the responsibility of the FBG.

Field and Laboratory Methods

On the lake, a dissolved oxygen and temperature profile was taken using a Yellow Springs Instruments Model 54A Oxygen/Temperature meter with a submersible probe. Readings were taken at one-meter intervals throughout the epilimnion and hypolimnion, and at one-half meter intervals through the metalimnion.

Sunlight and skylight penetration into the water was measured with a Whitney submersible photometer model LMA-8A, off the sunny side of the boat. The coefficient of light extinction was calculated from the relative light intensities measured.

Samples of lake water chemistry to be analyzed for dissolved oxygen, alkalinity, free (unbound) carbon dioxide, pH, and specific conductivity were collected with a 3-liter Van Dorn

bottle at depths which represented the surface, mid-epilimnion, metalimnion, and hypolimnion. Alkalinity, free carbon dioxide, and pH samples were stored on ice in 250 milliliter polyethylene bottles and were analyzed in the field within 1 to 2 hours of sampling. Specific conductivity samples were analyzed in the FBG lab at room temperature.

In addition to the oxygen profile taken, the dissolved oxygen (DO) concentration of specific lakewater samples (epilimnetic and hypolimnetic) were determined chemically with the azide modification of the Winkler method (EPA 1979). The precision of the method provides a standard for the electronic probe. Water is collected in 350 ml biological oxygen demand (BOD) bottles and fixed with two reagents, manganese sulfate and alkali-iodine-azide. A loose precipitate (floc) of manganic hydroxide forms that is equivalent to all dissolved oxygen originally present in the sample. Concentrated sulphuric acid is added to the bottle which causes a stoichiometric release of dissolved iodine equal to the original amount of dissolved oxygen present. A known quantity of sample is then titrated to an equivalence point using .0250N phenylarsine oxide titrant (similar to, but more stable than, sodium thiosulphate which may also be used) and a starch indicator solution. The end-point is reached when the purple colored iodine-starch complex is reduced and the solution becomes colorless. The amount of titrant added is recorded to the nearest 0.1 ml and concentrations are reported to the nearest 0.2 milligrams dissolved oxygen per liter.

To determine the alkalinity, lake water samples were titrated with 0.002 N sulphuric acid in the presence of the indicator methyl red/bromocresol green to a pH of 5.1 (grey endpoint) and 4.6 (pink endpoint). The amount of titrant used (dilute sulphuric acid) was recorded to the nearest 0.1 ml, equivalent to milligrams of calcium carbonate per liter. Values reported can be converted to microequivalents of calcium carbonate using a multiplication factor of 20.

"Free" carbon dioxide concentration was determined by titrating the fresh lakewater samples with 0.0027 N sodium hydroxide to a final endpoint pH of 8.3, in the presence of the indicator dye phenolphthalein.

Lakewater pH was measured with a digital pH meter (Beckman model phi 44) equipped with a combination probe (Orion Co.) and an automatic temperature compensating probe. The meter was calibrated with pH 4 and pH 7 buffer solutions and then the probe was allowed to equilibrate in the lake water for at least thirty minutes prior to sample analysis.

Specific conductivity was measured with a Barnstead Conductivity Bridge Model PM-70CB , with a model B-10 probe (cell constant = 1.0). Corrections were made for sample temperatures with a standard curve of potassium chloride solution conductivity versus temperature. Results are reported as micro-Siemans (uS; where uS equals umho cm^{-2}) standardized to 18° C.

Samples to be analyzed for chlorophyll a, total phosphorus, and phytoplankton were collected with a vertical tube sampler into a 2.5 liter dark plastic bottle. Chlorophyll samples were filtered through a 0.45 micron membrane filter and air-dried in the dark until analysis. The chlorophyll a content was analyzed by extracting the chlorophyll with a 95% acetone solution saturated with magnesium carbonate. The samples were then centrifuged and their light absorbance read at two standard wavelengths (663 and 750 nanometers) with a Baush and Lomb model 710 spectrophotometer equipped with 50mm cuvettes. An absorptivity value of $84 \text{ gm liter}^{-1} \text{ cm}^{-1}$ (Vollenweider 1969) was used for calculating the concentrations.

Dissolved color samples of the filtrate from FBG and lay monitor chlorophyll filtrations was determined by reading the absorbance of the samples at two different wavelengths (440 and 493 nanometers) in a 50mm light path. The two readings were converted to the more widely used platinum cobalt color values (ptu) using standard curves of the absorbance of chloroplatinate.

Phosphorus samples were preserved with 1.0 milliliter of concentrated sulphuric acid and refrigerated until analysis. Also, phosphorus samples from lay monitors were received by the FBG in a refrigerated or frozen state, and stored cold until analysis. To determine the total phosphorus content, ammonium persulfate and 11 N sulfuric acid was added to digest the total phosphorus, and the samples were autoclaved for thirty minutes at 250 to 260 degrees C. Reagents included potassium antimony

tartrate, ammonium molybdate, and a solution of ascorbic acid mixed fresh before each sample run (E.P.A. 1979). Absorbance of the blue phosphorus complex was measured with a spectrophotometer at 650 nanometers. A standard curve of the absorbance of a potassium phosphate (monobasic) solution to convert the readings to total phosphorus concentrations. Each sample was analyzed twice and an average of the two values taken as the phosphorus content in parts per billion (ppb).

Phytoplankton samples were preserved with iodine (Lugol's solution) immediately after collection. Algae were later identified and counted with an inverted microscope after settling for 24 hours in 5 or 10 ml counting chambers. At least 200 individual algal "units" were counted with a modified scan technique (Baker, 1973). Phytoplankton are reported to species level whenever possible.

Zooplankton samples were collected with a plankton net (30 centimeter diameter, 150 micron porosity) towed vertically through the oxygenated portion of the water (>0.5 ppm oxygen). Samples were immediately preserved in a 4% formalin-sucrose solution (Haney and Hall, 1973). Organisms were identified to species whenever possible. Subsampling, whenever necessary, was done with a 1 ml Hensen-Stemple pipette. Repeated subsamples were analyzed until at least 100 organisms were counted.

Data analysis

Incoming data are received through the mail during the sampling season and are first filed in an "incoming data" book.

This provides temporary storage until the corresponding chlorophyll and/or phosphorus sample for each data sheet is analyzed. All data, including date, lake, site, secchi disk depth, chlorophyll a and phosphorus concentrations, alkalinity, and color measurements, are filed and stored on the FBG computerized data-management system that utilizes a mainframe DEC VAX-8650 computer and an IBM compatible microcomputer (Zenith Data Systems 158). With full use of relational data bases, such as S1032 and Dbase III+ data can be easily retrieved by lake, date, station or by parameter and used for individual reports and program summaries for each year.

Statistical treatment of the data from each lake, produced for level III reports, includes a comparison of seasonal tendencies found throughout the year, monthly means for the different parameters tested, and confidence levels for each site. The same comparisons are made on a yearly basis if the lake has been in the program for two years or more. Where sufficient data are available from several years, regression analyses and other statistical tests can be performed. Such analyses may identify trends and help explain variations in the data (eg. secchi disk depth, chlorophyll a, color). In addition, data from a lake may be compared with other lakes in the program, other computerized data bases (New Hampshire Water Supply and Pollution Control, New Hampshire Fish and Game, EPA Surface Water Survey and others) and to published water quality classifications.

Trophic boundaries of Forsberg and Ryding (1980) of transparency, chlorophyll a, and total phosphorus are used as criteria in discussions of the trophic state of the program lakes. Phytoplankton are reported both as species and classes. Crustacean zooplankton were classified into one of four categories depending on their size (large or small) and their feeding preferences (herbivore or predator) with a modified version of criteria from Sprules (1980). The differences in abundance between the different groups allow for a more complete description of the zooplankton community and the trophic classification of lakes.

